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(54) Title: CHIMERIC PROTEINS FOR CELL TARGETING AND APOPTOSIS INDUCTION AND METHODS OF USING THE SAME

(57) Abstract: Fusion proteins which comprise an apoptosis inducing protein portion and a cell targeting portion are disclosed. Fusion proteins which comprise a protease portion and a cell targeting portion are disclosed. Compositions for and methods of targeting and inducing the death of cells are disclosed.

CHIMERIC PROTEINS FOR CELL TARGETING AND APOPTOSIS INDUCTION AND METHODS OF USING THE SAME

FIELD OF THE INVENTION

The invention relates to compositions and methods for selectively targeting cells for apoptosis induced cell death. The invention relates to compositions and methods for selectively targeting cells for cell death.

BACKGROUND OF THE INVENTION

The core protein of West Nile Virus (WNV) has recently been identified as being capable of inducing apoptosis in cell in which it is present. This observation is described in PCT Application Number PCT/US01/31355, which is incorporated herein by reference.

Similarly, the HIV accessory protein Vpr has been identified as being capable of cell cycle arrest and the induction of apoptosis. This observation is described in PCT application PCT/US01/10028, which is incorporated herein by reference.

In addition to these proteins, other proteins such as caspase have been known to induce apoptosis in cells.

There remains a need for compositions and methods which can incorporate the activity of apoptosis inducing proteins into effective compositions useful in methods of eliminating specific cells.

SUMMARY OF THE INVENTION

The present invention provides fusion proteins which comprise an apoptosis inducing protein portion and a cell targeting portion.

The present invention provides compositions for and methods of targeting and inducing the death of cells. The present invention relates to a method of inducing cell death which comprises the step of contacting cells with an amount of a fusion protein which comprises an apoptosis inducing protein portion and a cell targeting portion. The fusion protein is administered in an amount effective to induce cell death.

The present invention provides fusion proteins which comprise a protease portion and a cell targeting portion

The present invention provides compositions for and methods of targeting and inducing the death of cells. The present invention relates to a method of inducing cell death which comprises the step of contacting cells with an amount of a fusion protein which comprises an protease portion and a cell targeting portion. The fusion protein is administered in an amount effective to induce cell death

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As used herein, the term "apoptosis-inducing protein" and "AIP" are used interchangeably and meant to refer to proteins or fragments thereof which induce apoptosis in cell when they are present in such cells.

As used herein, the term "protease portion is meant to refer to the portions of fusion proteins which are protease sequences or fragments thereof which retain there ability to function as proteases or be converted into active proteases.

As used herein, the terms "induce" and "inducing" in reference to cell death or apoptosis refer to activities that initiate events that lead to cell death, including activities that initiate cellular events that are part of an apoptotic pathway that contribute to cell death.

As used herein, the term "apoptosis" refers to the form of eukaryotic cellular death, which is distinct form necrosis, and which includes cytoskeletal disruption, cytoplasmic shrinkage and condensation, expression of phosphatidylserine on the outer surface of the cell membrane and blebbing, resulting in the formation of cell membrane

bound vesicles or apoptotic bodies. For a review of apoptotic cell death see, *e.g.*, Utz & Anderson, 2000, Life and death decisions: regulation of apoptosis by proteolysis of signaling molecules, Cell Death Differ., 7:589-602.

As used in this specification and the appended claims, the singular forms "a," "an" and "the" include plural references unless the content clearly dictates otherwise. Thus, for example, reference to "a cell" includes a mixture of two or more cells.

As used herein, the phrases "amount effective to induce cell death" and "level effective to induce cell death" in reference to capsid protein, or functional fragments thereof, means that the amount of capsid protein, or functional fragment thereof, in contact with a cell, or the level of capsid protein, or functional fragment thereof, expressed in the cell, is effective to trigger the events that will kill the cell.

As used herein, the term "protein" refers to a polymer of amino acid residues, and is not limited to a minimum length. Polypeptides, peptides, oligopeptides, dimers, multimers, and the like, are included in the definition. Both full length proteins and fragments thereof are contemplated by the definition. The term also includes post-expression modifications to the protein, including, but not limited to, glycosylation, acetylation, phosphorylation.

As used herein, "injectable pharmaceutical composition" refers to pharmaceutically acceptable compositions for use in patients that are sterile, pyrogen-free, and free of any particulates. *See*, *Remington's Pharmaceutical Sciences*, 18th Ed., Gennaro, ed., Mack Publishing Co., Easton, PA, 1990 and U.S.P.

As used herein, "pharmaceutically acceptable carrier" includes any carrier that does not itself induce a harmful effect to the individual receiving the composition. For example, a "pharmaceutically acceptable carrier" should not induce the production of antibodies harmful to the recipient. Suitable "pharmaceutically acceptable carriers" are known to those of skill in the art and are described in *Remington's Pharmaceutical Sciences*, *supra*.

As used herein, "hyperproliferating cells" refers to cells that are growing, dividing, or proliferating at an inappropriate or non-normal time or place, and includes cells that have entered the cell cycle when they should be in G_0 or in a quiescent state. For example, tumor cells are included within the meaning of "hyperproliferating cells."

Diseases or conditions characterized by or associated with "hyperproliferating cells" include cancer, autoimmunity, non-malignant growths, and psoriasis.

As used herein, "treating" includes the amelioration and/or elimination of a disease or condition characterized by or associated with hyperproliferating cells.

As used herein, "individual" refers to human and non-human animals that can be treated with pharmaceutical compositions of the invention.

As used herein, the term "administering" includes, but is not limited to, intra-tumoral injection, transdermal, parenteral, subcutaneous, intra-muscular, oral, and topical delivery.

As used herein, "intra-tumoral injection" in reference to administration of pharmaceutical compositions refers to the direct introduction of the pharmaceutical composition into a tumor site by injection.

The present invention arises out of the discovery of the apoptosis-inducing activity of the WNV capsid (Cp) protein in tumor-derived cells, the similar activity of HIV accessory protein Vpr, the apoptosis inducing activity of the mitochondrial protein AIF, and various other endogenous proteins such as Caspases. It has been discovered that the presence of these AIPs in cells leads to the induction of an apoptotic pathway and, ultimately, to the death of cells. The apoptosis-inducing activity of AIPs renders them useful in methods of killing rapidly growing cells, including cancer cells and immune cells involved in autoimmune disease.

According to some aspects of the present invention, fusion proteins are provided which comprise an AIP portion linked to a targeting portion which is a specific ligand for a protein expressed by the cell type which is to be targeted for destruction. The ligand may be a natural ligand, an antibody or fragment thereof or another type of molecule that binds with specificity to a cellular protein.

According to some aspects of the present invention, fusion proteins are provided with a protease portion linked to a targeting portion which is a specific ligand for a protein expressed by the cell type which is to be targeted for destruction. The ligand may be a natural ligand, an antibody or fragment thereof or another type of molecule that binds with specificity to a cellular protein. Examples of proteases are TAP.

Depending upon the cell being targeted for destruction, the fusion proteins are useful to treat a variety of diseases. For example, if the ligand targets an protein expressed by tumor cells, the fusion protein is useful to treat cancer and reduce or eliminate tumor burden. If the ligand targets an protein expressed by particularly immune cells, the fusion protein is useful to treat autoimmune disease. Other disease may be similarly treated by the selective elimination of cells.

In some embodiments, the ligand can be a known ligand for a target cellular protein.

Examples of ligands include ligands that are specific for costimulatory molecules, cytokines (ligand for cytokine receptor), growth factors (ligand for growth factor receptor) and chemokines (ligand for chemokine receptor). Other ligands are antibodies including recombinant antibodies, antibody fragments which specifically bind to target cellular proteins such as erbB2, PSMA, Flt-3, cytokine receptors, growth factor receptors and chemokine receptors. Examples of ligands include CD28 and CTLA-4 which are both natural ligands for CD80. CD28 is also a natural ligand for CD86. The natural ligand for CD40 is CD40L, the natural ligand for ICOSL is ICOS, the natural ligand for ICAM-1 is LFA-3, the natural ligand for 41BB is 41BBL, the natural ligand for MCSFR is MCSF, the natural ligand for FT3 is FL3L, the natural ligand for CCR2, CCR3 and CCR5 are MCP-3, and RANTES. Human proinflammatory cytokines include IL-1α binds to IL-1 receptors and TNF-α and TNF-β bind to TNF receptors. The Th1 cytokines include IL-2, IL-15, and IL-18, and Th2 cytokines include IL-4, IL-5 and IL-10 bind to their respective receptors. GM-CSF is another factor which may be used to target cells according to the invention.

The fusion protein may include a protease cleavage site between the AIP portion and the ligand portion or between the protease portion and the ligand portion. An example of such a cleavage site is the cleavage site recognized by a protease known to be present in the cell targeted for elimination.

The practice of the present invention employs conventional methods molecular biology and recombinant DNA techniques within the skill of the art. Such techniques are explained fully in the literature. See, *e.g.*, Sambrook *et al.*, eds., Molecular Cloning: A Laboratory Manual (2nd ed.) Cold Spring Harbor Laboratory Press, Cold

Spring Harbor, NY (1989); Ausubel *et al.*, eds., Current Protocols in Molecular Biology, John Wiley & Sons, New York, NY (2000); Glover, ed., DNA Cloning: A Practical Approach, Vols. I & II; Colowick & Kaplan, eds., Methods in Enzymology, Academic Press; Weir & Blackwell, eds., Handbook of Experimental Immunology, Vols. I-IV, Blackwell Scientific Pubs. (1986); Fields, Knipe, & Howley, eds., Fields Virology (3rd ed.) Vols. I & II, Lippincott Williams & Wilkins Pubs. (1996); Coligan *et al.*, eds., Current Protocols in Immunology, John Wiley & Sons, New York, NY (2000), each of which is incorporated herein by reference.

The identification of functional fragments of proteins that induce apoptosis can be undertaken and achieved routinely capsid protein. Likewise, the identification of ligands can be routinely achieved. The construction of fusion proteins which comprise an AIP portion that retains its activity and ligand portion that retains its activity can be accomplished. One having ordinary skill in the art can readily determine whether fusion protein will target the cell and induce apoposis.

Therapeutic aspects of the invention include use of the fusion proteins to treat diseases associated with hyperproliferating cells such as cancer or psoriasis and autoimmune disease by selectively targeting cells for apoptosis induced death. The present invention relates to pharmaceutical compositions that comprise such fusion proteins. Pharmaceutical compositions of the present invention are particularly useful for treating cancer characterized by solid tumors. The ability to stimulate hyperproliferating cells to undergo apoptotic death provides a means to disrupt the hyperproliferation of the cells, thereby decreasing the tumor. In diseases such as cancer and psoriasis which are characterized by the inappropriate hyperproliferation of cells, the pharmaceutical composition is useful to arrest the hyperproliferation through an induction of an apoptotic cell death, thereby effectuating a treatment of the disease.

WNV capsid protein, or functional fragments thereof, may be produced by routine means using readily available starting materials as described above. The nucleic acid sequence encoding WNV capsid protein as well as the amino acid sequence of the protein are well known. The entire genome for a number of WNV isolates are published and available in GenBank, including isolate 2741 (accession number AF206518), strain NY99-flamingo382-99 (accession number AF196835), and the isolate identified as

accession number M12294, each of which is incorporated herein by reference. There are a variety of publications relating to sequence information for the WNV genome, citations of which are linked to the sequence information in GenBank. Each of these references, including the publicly available sequence information, are incorporated herein by reference.

Sequence information for capsid proteins and nucleic acids from other *Flaviviridae* viruses can also be found in GenBank. By way of non-limiting examples, complete genome sequences of strains and isolates provided in GenBank include, JEV (accession number M18370, D90194, and D90195), SLEV (accession number M16614), YFV (accession numbers AF094612, U17067, U17066, U54798, U21055, U21056, and X03700), DENV (accession numbers M23027, U88535, U88536, and U88537), BVDV (accession number M31182), and HCV (accession number AF207773 and AF207774), each of which is incorporated herein by reference. Other AIP sequences such as HIV Vpr and various caspases are well known. The amino acid sequence of Vpr is disclosed in U.S. Serial Number 08/167,608 filed December 15, 1993, which is incorporated herein by reference. Data from Vpr protein mapping experiments to identify regions that specifically interact with and arrest cell cycle arrest are described in Provisional Application 60/055,754 filed August 14, 1997, which is incorporated herein by reference.

One having ordinary skill in the art may use commercially available expression vectors and systems or produce vectors using well known methods and readily available starting materials to produce the fusion proteins. Expression systems containing the requisite control sequences, such as promoters and polyadenylation signals, and preferably enhancers, are readily available and known in the art for a variety of hosts. *See, e.g.*, Current Protocols in Molecular Biology, John Wiley & Sons, New York, NY (2000). Thus, the desired proteins can be prepared in both prokaryotic and eukaryotic systems, resulting in a spectrum of processed forms of the protein.

The most commonly used prokaryotic system remains *E. coli*, although other systems such as *Bacillus subtilis* and *Pseudomonas* are also useful. Suitable control sequences for prokaryotic systems include both constitutive and inducible promoters including, but not limited to, the *lac* promoter, the *trp* promoter, hybrid promoters such as the tac promoter, the lambda phage Pl promoter. In general, foreign proteins may be

produced in these hosts either as fusion or mature proteins. When the desired sequences are produced as mature proteins, the sequence produced may be preceded by a methionine which is not necessarily efficiently removed. Accordingly, the peptides and proteins claimed herein may be preceded by an N-terminal Met when produced in bacteria. Moreover, constructs may be made wherein the coding sequence for the peptide is preceded by an operable signal peptide which results in the secretion of the protein. When produced in prokaryotic hosts in this matter, the signal sequence is removed upon secretion.

A wide variety of eukaryotic hosts are also now available for production of recombinant foreign proteins. As in bacteria, eukaryotic hosts may be transformed with expression systems which produce the desired protein directly, but more commonly signal sequences are provided to effect the secretion of the protein. Eukaryotic systems have the additional advantage that they are able to process introns which may occur in the genomic sequences encoding proteins of higher organisms. Eukaryotic systems also provide a variety of processing mechanisms which result in, for example, glycosylation, carboxy-terminal amidation, oxidation or derivatization of certain amino acid residues, conformational control, and so forth.

Commonly used eukaryotic systems include, but are not limited to, yeast cells, fungal cells, insect cells, mammalian cells, avian cells, and cells of higher plants. Suitable promoters are available which are compatible and operable for use in each of these host cell types. Also available, are termination sequences and enhancers, such as, for example, the baculovirus polyhedron promoter. As described above, promoters can be either constitutive or inducible. For example, in mammalian systems, the mouse metallothionine promoter can be induced by the addition of heavy metal ions.

The particulars for the construction of expression systems suitable for desired hosts are known to those in the art. For recombinant production of the protein, the DNA encoding it is suitably ligated into the expression vector of choice and then used to transform the compatible host which is then cultured and maintained under conditions wherein expression of the foreign gene takes place. The protein of the present invention thus produced is recovered from the culture, either by lysing the cells or from the culture medium as appropriate and known to those in the art.

One having ordinary skill in the art can, using well known techniques, isolate the fusion protein produced using such expression systems.

In addition to producing these proteins by recombinant techniques, automated amino acid synthesizers may also be employed to produce fusion proteins. It should be further noted that if the proteins herein are made synthetically, substitution by amino acids which are not encoded by the gene may also be made. Alternative residues include, for example, the amino acids of the formula H2N(CH2)nCOOH wherein n is 2-6. These are neutral, nonpolar amino acids, as are sarcosine (Sar), t-butylalanine (t-BuAla), t-butylglycine (t-BuGly), N-methyl isoleucine (N-MeIle), and norleucine (Nleu). Phenylglycine, for example, can be substituted for Trp, Tyr or Phe, an aromatic neutral amino acid; citrulline (Cit) and methionine sulfoxide (MSO) are polar but neutral, cyclohexyl alanine (Cha) is neutral and nonpolar, cysteic acid (Cya) is acidic, and ornithine (Orn) is basic. The conformation conferring properties of the proline residues may be obtained if one or more of these is substituted by hydroxyproline (Hyp).

Pharmaceutical compositions used for treating autoimmiune diseases and diseases characterized by hyperproliferating cells comprising fusion protein and a pharmaceutically acceptable carrier or diluent may be formulated by one of skill in the art with compositions selected depending upon the chosen mode of administration. Suitable pharmaceutical carriers are described in *Remington's Pharmaceutical Sciences*, *supra*., a standard reference text in this field.

A common requirement for any route of administration is efficient and easy delivery. In one embodiment of the invention, the compositions are administered by injection. In a preferred embodiment, the compositions are administered by intra-tumoral injection. Other means of administration include, but are not limited to, transdermal, transcutaneous, subcutaneous, intraperitoneal, mucosal, or general persistent administration.

For parenteral administration, the *Flaviviridae* capsid protein, or functional fragment thereof, can be, for example, formulated as a solution, suspension, emulsion or lyophilized powder in association with a pharmaceutically acceptable parenteral vehicle. Examples of such vehicles are water, saline, Ringer's solution, dextrose solution, and 5% human serum albumin. Liposomes and nonaqueous vehicles such as fixed oils may also

be used. The vehicle or lyophilized powder may contain additives that maintain isotonicity (*e.g.*, sodium chloride, mannitol) and chemical stability (e.g., buffers and preservatives). The formulation is sterilized by commonly used techniques. For example, a parenteral composition suitable for administration by injection is prepared by dissolving 1.5% by weight of active ingredient in 0.9% sodium chloride solution.

Although individual needs may vary, the determination of optimal ranges for effective amounts of formulations is within the skill of the art. Human doses can also readily be extrapolated from animal studies (Katocs *et al.*, Chapter 27 *In: Remington's Pharmaceutical Sciences*, 18th Ed., Gennaro, ed., Mack Publishing Co., Easton, PA, 1990). Generally, the dosage required to provide an effective amount of a formulation, which can be adjusted by one skilled in the art, will vary depending on several factors, including the age, health, physical condition, weight, type and extent of the disease or disorder of the recipient, frequency of treatment, the nature of concurrent therapy, if required, and the nature and scope of the desired effect(s) (Nies *et al.*, Chapter 3 *In: Goodman & Gilman's The Pharmacological Basis of Therapeutics*, 9th Ed., Hardman *et al.*, eds., McGraw-Hill, New York, NY, 1996). Usually, a daily dosage of fusion protein can be about 1μg to 100 milligrams per kilogram of body weight. Ordinarily 0.5 to 50, and preferably 1 to 10 milligrams per kilogram per day given in divided doses 1 to 6 times a day or in sustained release form is effective to obtain desired results.

The pharmaceutical compositions according to the present invention may be administered as a single doses or in multiple doses. The pharmaceutical compositions of the present invention may be administered either as individual therapeutic agents or in combination with other therapeutic agents. The treatments of the present invention may be combined with conventional therapies, which may be administered sequentially or simultaneously.

The pharmaceutical compositions comprising fusion protein may be administered by any means that enables the active agent to reach the agent's site of action in the body of the recipient. Because proteins are subject to digestion when administered orally, parenteral administration, *i.e.*, intravenous, subcutaneous, intramuscular, would ordinarily be used to optimize absorption. In addition, the pharmaceutical compositions of the present invention may be injected at a site at or near hyperproliferative growth. For

example, administration may be by direct injection into a solid tumor mass or in the tissue directly adjacent thereto. If the individual to be treated is suffering from psoriasis, the fusion protein may be formulated with a pharmaceutically acceptable topical carrier and the formulation may be administered topically as a creme, lotion or ointment for example.

EXAMPLE

The following sequences identified by accession number and references are incorporated herein by reference.

West Nile Virus	AF202541	strain HNY1999
West Nile Virus	NC 001563	complete genome
HIV Vpr		
VPR	AJ404325	vpr, gag, pol, vif, vpu, env, and nef
VPR	AF316862	vif, vpr (Cameroon isolate)
VPR	AF325763	vif, vpr (South African isolate)
AIF		
AIF	XM 010246	also called "programmed cell death 8" or "PDCD8"
AIF	NM 004208	
TAP		
TAP	AF009510	also called tapasin
TAP	AF314222	alternatively spliced
TAP	AB010639	Tapasin 2

Macrophage Colony-Stimulating Factor

Accession No. AAA59572

Cerretti, D.P. et al., Mol. Immunol. 25 (8), 761-770 (1988)

Accession No. AAB51235

Visvader, J. and Verma, I.M., Mol. Cell. Biol. 9 (3) 1336-1341 (1989)

Accession No. P09603: Wong et al. Science 235 (4795) 1504-1508 (1987)

Cerretti et al. Mol. Immunol. 25 (8) 761-770 (1988)

Kawasaki et al., Science 230 (4723) 291-296 (1985)

Chemokine (C-C motif) receptor 5

Accession No. 4502639

Raport, C.J. et al., J. Biol. Chem. 271 (29), 17161-17166 (1996)

Monocyte Chemoattractant Protein (MCP-3)

Accession No. CAA50407

Minty, A. et al., Eur. Cytokine Netw. 4 (2), 99-110 (1993)

Accession No. AAC03538

pFLT3

fms-related tyrosine kinase 3

Accession No. 4758396

Small, D. et al., Proc. Natl. Acad. Sci. U.S.A. 91, 459-463 (1994)

Accession No. P36888

Small et al., Proc. Natl. Acad. Sci. U.S.A. 91, 459-463 (1994)

pFLT3LG

fms-related tyrosine kinase 3 ligand

Accession No. 4503751

4-1BB

Accession No. AAA53133

Alderson, M.R. et al., Eur. J. Immunol. 24 (9), 2219-2227 (1994)

4-1BBL

Accession No. P41273

Alderson, M.R. et al., Eur. J. Immunol. 24 (9) 2219-2227 (1994)

RANTES

Accession No. BAA76939

Liu, H. et al., PNAS U.S.A. 96 (8), 4581-4585 (1999)

Accession No. 1065018

Accession No. XM 012656

Accession No. NM 002985

CCR1/MIP1R

Accession No. P32246

Neote, K. et al., Cell 72 (3) 415-425 (1993)

Gao, J.L. et al., J. Exp. Med. 177 (5) 1421-1427 (1993)

Nomura, H. et al., Int. Immunol. 5 (10) 1239-1249 (1993)

CCR5

Accession No. P56493

Kuhmann, S.E. et al., J. Virol. 71 (11) 8642-8656 (1997)

Murayama, Y. et al.

CCR2

Accession No. P41597

Charo, I.F. et al., PNAS, U.S.A. 91 (7) 2752-2756 (1994)

Yamagami, S. et al., Biochem. Biophys. Res. Commun. 202 (2) 1156-1162 (1994)

Wong, L.M. et al., J. Biol. Chem. 272 (2) 1038-1045 (1997)

CCR3

Accession No. P51677

Combadiere, C. et al., J. Biol. Chem. 270 (28) 16491-16494 (1995)

Combadiere, C. et al., J. Biol. Chem. 270 30235 (1995)

Dougherty, B.L. et al., J. Exp. Med. 183 (5) 2349-2354 (1996)

CD40 ligand

Accession No. P29965

Graf, D. et al., Eur. J. Immunol. 22 (12) 3191-3194 (1992)

Hollenbaugh, D. et al., Embo. J. 11 (12) 4313-4321 (1992)

Spriggs, M.K. et al., Cell 72 291-300 (1993)

Spriggs, M.K. et al., J. Exp. Med. 176 (6) 1543-1550 (1992)

Gauchat et al., Febs. Lett. 315 (3) 259-266 (1993)

CD86

Accession No. 5901920

Azuma et al., Nature 366 (6450) 76-79 (1993)

Reeves et al., Mamm. Genome 8 (8) 581-582 (1997)

CD80

Accession No. 4885123

Selvakumar et al., Immunogenetic 36 (3) 175-181 (1992)

Freeman et al., Blood 79 (2) 489-494 (1992)

CD40

Accession No. 4507581

Stamenkovic et al., Embo. J. 8 (5) 1403-1410 (1989)

LFA-3

Accession No. BAA05922

ICAM1

Accession No. AAB51145

CD28

Accession No. 5453611

Lee et al., J. Immunol. 145 (1) 344-352 (1990)

The nucleotide and amino acid sequences of human IL-1α are well known and set forth in Telford, et al. (1986) Nucl. Acids Res. 14:9955-9963, Furutani, et al. (1985) Nucl. Acids Res. 14:3167-3179, March, et al. (1985) Nature 315:641-647, and accession code Swissprot PO1583, which are each incorporated herein by reference.

The nucleotide and amino acid sequences of human IL-2 are well known and set forth in Holbrook, et al. (1984) Proc. Natl. Acad. Sci. USA 81:1634-1638, Fujita, et al. (1983) Proc. Natl. Acad. Sci. USA 80:7437-7441, Fuse, et al. (1984) Nucl. Acids Res. 12:9323-9331, Taniguchi, et al. (1983) Nature 302:305-310, Maeda, et al. (1983) Biochem. Biophys. Res. Comm. 115:1040-1047, Devos, et al. (1983) Nucl. Acids Res. 11:4307-4323, and accession code Swissprot PO1585, which are each incorporated herein by reference.

The nucleotide and amino acid sequences of human IL-4 are well known and set forth in Arai, et al. (1989) J. Immunol. 142:274-282, Otsuka, et al. (1987) Nucl. Acids Res. 15:333-344, Yokota, et al. (1986) Proc. Natl. Acad. Sci. USA 83:5894-5898, Noma, et al. (1984) Nature 319:640-646, Lee, et al. (1986) Proc. Natl. Acad. Sci. USA 83:2061-2063, and accession code Swissprot 05112 (the accession code for murine IL-4 is Swissprot 07750) , which are each incorporated herein by reference.

The nucleotide and amino acid sequences of human IL-5 are well known and set forth in Campbell, et al. (1987) Proc. Natl. Acad. Sci. USA 84:6629-6633, Tanabe, et al. (1987) J. Biol. Chem. 262:16580-16584, Campbell, et al. (1988) Eur. J. Biochem. 174:345-352, Azuma, et al. (1986) Nucl. Acids Res. 14:9149-9158, Yokota, et al. (1986) Proc. Natl. Acad. Sci. USA 84:7388-7392, and accession code Swissprot PO5113, which are each incorporated herein by reference.

The nucleotide and amino acid sequences of human IL-10 are well known and set forth in Viera, et al. (1991) Proc. Natl. Acad. Sci. USA 88:1172-1176, and accession code Swissprot P22301.

The nucleotide and amino acid sequences of human IL-15 are well known and set forth in Grabstein, et al. (1994) Science 264:965-968, and accession code Swissprot U03099, which are each incorporated herein by reference.

The nucleotide and amino acid sequences of human IL-18 are well known and set forth in Ushio, et al. (1996) J. Immunol. 156:4274-4279, and accession code D49950, which are each incorporated herein by reference.

The nucleotide and amino acid sequences of human TNF-α are well known and set forth in Pennica, (1984) Nature 312:724-729, and accession code Swissprot PO1375, which are each incorporated herein by reference.

The nucleotide and amino acid sequences of human TNF-β are well known and set forth in Gray, (1984) Nature 312:721-724, and accession code Swissprot PO1374, which are each incorporated herein by reference.

CLAIMS

1. A fusion protein comprising an AIP portion and a ligand portion.

2. The fusion protein of claim 1 wherein the AIP portion is derived from WNV capsid, HIV Vpr, or a caspase.

3. The fusion protein of claim 1 wherein the ligand is a natural ligand.

4. The fusion protein of claim 3 wherein the ligand is a natural ligand selected from the group consisting of costimulatory molecule ligands, cytokines, chemokines and growth factors.

5. The fusion protein of claim 4 wherein the ligand is a natural ligand selected from the group consisting of Flt-3 ligand, IL-15 or RANTES.

6. The fusion protein of claim 1 wherein the ligand is an antibody.

7. The fusion protein of claim 6 wherein the ligand is an antibody fragment.

8. The fusion protein of claim 1 wherein the ligand is an antibody that binds to costimulatory molecule, cytokine receptors, chemokine receptors, growth factor receptors, oncogene products and cancer cell markers.

9. The fusion protein of claim 1 wherein the ligand is an antibody that binds to erbB2 protein, PSMA protein and Flt-3.

10. A method of eliminating a cell comprising contacting the cell with a fusion protein of claim 1.

11. A method of eliminating cells in an individual comprising administering to said individual a fusion protein of claim 1.

12. A fusion protein comprising a protease portion and a ligand portion.

13. The fusion protein of claim 12 wherein the protease portion is TAP or a fragment thereof.

14. The fusion protein of claim 12 wherein the ligand is a natural ligand.

15. The fusion protein of claim 14 wherein the ligand is a natural ligand selected from the group consisting of costimulatory molecule ligands, cytokines, chemokines and growth factors.

16. The fusion protein of claim 15 wherein the ligand is a natural ligand selected from the group consisting of Flt-3 ligand, IL-15 or RANTES.

17. The fusion protein of claim 12 wherein the ligand is an antibody.

18. The fusion protein of claim 17 wherein the ligand is an antibody fragment.

19. The fusion protein of claim 12 wherein the ligand is an antibody that binds to costimulatory molecule, cytokine receptors, chemokine receptors, growth factor receptors, oncogene products and cancer cell markers.

20. The fusion protein of claim 12 wherein the ligand is an antibody that binds to erbB2 protein, PSMA protein and Flt-3.

21. A method of eliminating a cell comprising contacting the cell with a fusion protein of claim 12.

22. A method of eliminating cells in an individual comprising administering to said individual a fusion protein of claim 12.

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Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/097042 A3

(54) Title: CHIMERIC PROTEINS FOR CELL TARGETING AND APOPTOSIS INDUCTION AND METHODS OF USING THE SAME

(57) Abstract: Fusion proteins which comprise an apoptosis inducing protein portion and a cell targeting portion are disclosed. Fusion proteins which comprise a protease portion and a cell targeting portion are disclosed. Compositions for and methods of targeting and inducing the death of cells are disclosed.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/16680

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C07K 14/715; A61K 38/19, 39/00
US CL : 530/351; 514/12; 424/185.1, 192.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 530/351; 514/12; 424/185.1, 192.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PLETNEV et al. West Nile virus/dengue Type 4 Virus Chimeras that are Reduced in Neurovirulence and Peripheral Virulence without Loss of Immunogenicity or Protective Efficacy	1-4, 10, 11
X --- Y	WO 99/45128 A2 (YISSUM RESEARCH DEVELOPMENT COMPANY OF THE HEBREW UNIVERSITY OF JERUSALEM) 10 September 1999 (10.09.99), see entire publication, especially abstract and claims.	1, 3, 10, 11 --- 2, 4
T	US 2002/0090374 A1 (YARKONI et al.) 11 July 2002 (11.07.02), see entire publication, especially abstract and claims.	1, 3, 10 and 11
T	US 2002/0164349 A1 (WEINER et al) 01 November 2002 (07.11.02), see entire publication, especially abstract and claims.	1-4, 10 and 11

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"B" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 August 2003 (10.08.2003)	04 SEP 2003
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer Eileen B. O'Hara Telephone No. (703) 308-0196

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/16680

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Continuation Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-4, 10 and 11

Remark on Protest
☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

PCT/US02/16680

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-11, drawn to fusion protein comprising an AIP portion and a ligand portion, and method of treatment. Within group I, see the species elections required below for the AIP portion and the ligand portion. If no additional fees are paid, Group I will be searched to the extent it reads on the first species named of each of the two groups of species, AIP portion that is derived from WNV capsid, and ligand portion that is a costimulatory molecule ligand, claims 1-4, 10 and 11.

Group II, claim(s) 12-22, drawn to fusion protein comprising a protease portion and ligand portion, and method of treatment. Within group II, see the species election required below for the ligand portion. If no additional fees are paid, Group II will be searched to the extent it reads on the first species named, ligand portion that is a costimulatory molecule ligand, claims 12-15, 21 and 22.

This application contains claims directed to more than one species of the generic invention. These species are deemed to lack unity of invention because they are not so linked as to form a single general inventive concept under PCT Rule 13.1.

In order for more than one species to be examined, the appropriate additional examination fees must be paid. The species are as follows:

For Group I only, AIP portion selected from: HIV Vpr and caspase.

For both Groups I and II, Ligand portion selected from: Cytokines (IL-15), chemokines (RANTES), growth factors (Flt-3), antibody to costimulatory molecule, antibody to cytokine receptors, antibody to growth factor receptors, antibody to oncogene products, antibody to cancer cell markers.

The claims are deemed to correspond to the species listed above in the following manner:

Claim 2, AIP portion from HIV Vpr and caspase.

Claims 4, 5, 15 and 16, cytokines, chemokines and growth factors.

Claims 8, 9, 19 and 20, antibody to costimulatory molecule, antibody to cytokine receptors, antibody to growth factor receptors, antibody to oncogene products, antibody to cancer cell markers.

The following claim(s) are generic: 1-3, 6-7, 10-14, 17, 18, 21 and 22.

Groups I and II are two separate inventions, and each species (10 in all) is an additional invention, resulting in 12 separate inventions.

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I corresponds to the first invention wherein the first product is the fusion protein comprising an AIP portion and a ligand portion, and method of treatment.
Note that there is no method of making the fusion protein. Groups II does not share the same or corresponding technical feature because group II is drawn to a the fusion protein comprising a protease portion and a ligand portion, and method of treatment. The fusion protein of group II comprises protease portion, which is a different type of protein having different activity than that of the AIP portion of group I. This authority therefore considers that the two inventions do not share a special technical feature within the meaning of PCT Rule 13.2 and thus do not relate to a single general inventive concept within the meaning of PCT Rule 13.1.

INTERNATIONAL SEARCH REPORT

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The species listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, the species lack the same or corresponding special technical features for the following reasons: they are different proteins having different structures and activities, and therefore do not share the same technical feature. This authority therefore considers that the several inventions do not share a special technical feature within the meaning of PCT Rule 13.2 and thus do not relate to a single general inventive concept within the meaning of PCT Rule 13.1.

Continuation of B. FIELDS SEARCHED Item 3:
EAST, STN/CAS, Medline
search terms: WNV, West Nile Virus, capsid, apoptosis, ligand, target, chimera, chimeric, fusion,